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TWR-32233 F42600-86-C-0001

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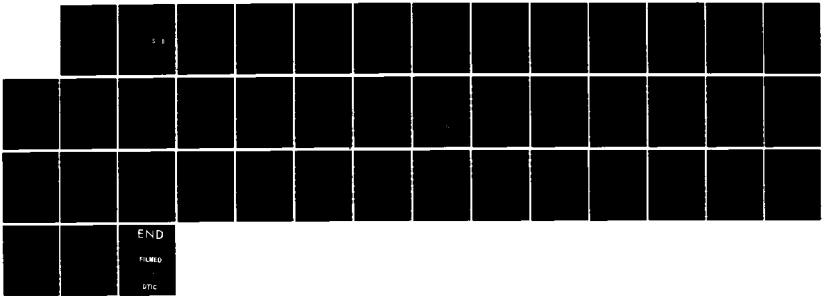

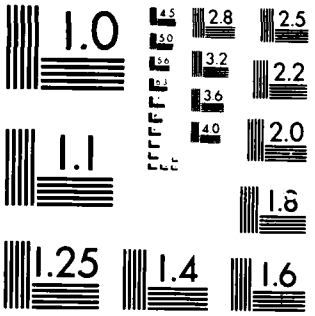

TWR-32233

AD-A164 840

Minuteman III
Third Stage Surveillance
Semiannual Report

January 1986

MORTON THIOKOL, INC.
Wasatch Operations
P.O. Box 524, Brigham City, Utah 84302 (801)863-3511

Publications No. 86370

86370-2.1

TWR-32233

MINUTEMAN III
STAGE III SURVEILLANCE
SEMIANNUAL REPORT

Prepared by

MORTON THIOKOL, INC.
WASATCH OPERATIONS
P.O. Box 524
Brigham City, Utah 84302

Contract F42600-86-C-0001

January 1986

Ralph Davis
Project Engineering

L. C. Porter, Jr., Program Manager
Minuteman Programs

Prepared for

AIR FORCE LOGISTICS COMMAND/OGDEN ALC
UNITED STATES AIR FORCE
HILL AFB, UTAH 84056

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ILLUSTRATIONS

TABLES

1.0 INTRODUCTION

This report presents the current status and general test results (1 Jun 1985 through 30 Nov 1985) for both the Morton Thiokol, Inc./Wasatch Operations and the Aerojet Solid Propulsion Co. (ASPC) Stage III Minuteman surveillance programs. The objective of the Morton Thiokol program is to compare the performance of those Morton Thiokol versus ASPC materials or components identified as having sufficient differences (processing, vendor, etc.) that the aging response might be affected. The materials and components compared are identified by TWR-3766, "Minuteman Age Sensitivity Component Review." Technical responsibility for the ASPC-initiated program was assigned to the Wasatch Operations on 1 Sep 1971, and the program has been continued in accordance with existing ASPC plans.

The surveillance program for the Minuteman III Stage III motor consists of storage and testing in eight general areas: (1) full-scale motors, (2) full-scale and subscale cases, (3) nozzles, (4) igniters, (5) liquid injection thrust vector control (LITVC) systems, (6) thrust termination systems, (7) roll control systems, and (8) electrical bonds. Results of all testing will be compared with failure criteria and/or specification values for the applicable parameters identified in PD III-018 to assess long term storage effects on motor performance.

2.0 PROGRAM STATUS

Contract F42600-86-C-0001 for engineering services for FY 86 was received during this reporting period. This contract includes essentially the same work scope as the FY 85 contract and covers the follow-on period of 20 Dec 1985 through 30 Sep 1986.

The program effort during this reporting period spanning the two contract periods consisted of laboratory testing of both the Morton Thiokol, Inc./ASPC Minuteman III Third Stage Surveillance components and material samples. In addition, bondline aging testing and analysis using samples from previously dissected motors was accomplished. The bondline aging data are included in the annual bondline aging study report.

In support of the program, all flight and static tests, for both First and Third Stage Minuteman motors, were reviewed and tabulated for incorporation into reliability and motor historical records. An array of the Minuteman III Third Stage motors tested, both flight test motors and static test (TOP motors) is presented in Table 5. The First Stage Minuteman motor tests are reported in the reliability/maintainability assessment and reliability test report.

An extension was received to contract F42600-84-C-1395 to support Ogden ALC in determining the cause of corrosion on Minuteman Stage I motor S/N 0014008 and establish inspection criteria, rework procedures for the Avcoat repair, and repair of the motor.

The program documentation status is presented in Table 1. The motor and component storage/testing status is summarized in Tables 2 through 5.

3.0 SUMMARY OF TESTING COMPLETED DURING THIS REPORT PERIOD

3.1 FULL-SCALE MOTORS

No full-scale motors were tested during this report period.

3.2 INSULATION (TP III-022)

After 192 months of storage at 80°F, testing was completed on the chamber insulation specimens. Test results were analyzed and the following trends noted:

V-45/V-57/Glass	Significant (increase)
V-45/203-220/Al	Significant (increase)
Cork/Glass	Significant (increase)
Mg/304/Cork	Significant (increase)
Al/Garlock/Glass	Significant (increase)

3.3 LITVC SYSTEM AND COMPONENTS (TP III-025)

Burst diaphragms were tested after 186 months of storage at pressures of 178 and 169 psig. The updated trend is not significant.

3.4 ROLL CONTROL (TP III-027)

Testing of the two roll control valves was not completed in time for inclusion in this report because of delay in receipt of the FY 86 contract.

4.0 TECHNICAL DISCUSSION

4.1 INSULATION (TP III-022)

Insulation specimens representing the age sensitive motor bond interfaces were aged 192 months and tested in accordance with TP III-022. Test results and failure modes are tabulated in Table 6.

4.1.1 Internal Insulation

The V-45/V-57/glass bond shear specimen mean is significantly different from previous data. The failure mode was 100 percent in the V-57/glass bond. The updated trend shown in Figure 1 indicates a significant increase in shear strength.

Aged V-45/A1 specimens used to simulate the internal insulation/aft boss were tested after 192 months storage. The mean is not significantly different from previous data. The failure mode was in the A1/203 interface. The updated trend shown in Figure 2 shows a significant increase in bond shear strength.

4.1.2 External Insulation

Two specimen configurations are used for the external insulation: (1) S-994 glass/Chemlok 304/2755 cork, and (2) HM21A-58 magnesium alloy/Chemlok 304/2755 cork. The glass/cork test results for 192 months storage are plotted in Figure 3 and show a significant upward trend. The failure was in the cork.

The magnesium/cork specimen test results after 192 months storage are shown on the upward trend (Figure 4). The failure mode is 100 percent in the cork.

4.1.3 Raceway Bond

The raceway bond specimens, aluminum/AF30/NOL7765/Chemlok 304/S-994 glass, aged 192 months and stored at 80°F, were tested during this report period. The updated trend (Figure 5) continues to show a significant upward trend in shear strength.

4.2 LITVC (TP III-025)

4.2.1 Burst Diaphragm Tests

Burst diaphragms stored in contact with strontium perchlorate and in a strontium perchlorate atmosphere were tested after 186 months storage at 80°F. The results of the burst tests and strontium perchlorate and free chlorides analyses are summarized in Table 7. The updated trend shown in Figure 6 is not significant. No evidence of intergranular, transgranular, or pitting corrosion was found during the metallographic examination.

5.0 SERVICE LIFE ESTIMATE

Demonstrated service life estimates are presented in Table 8. The major components being aged are listed in Table 9, along with failure criteria and TALE.

The latest surveillance data (extracted from the trend plots) show no parameters with a TALE less than 20 years.

6.0 PROGRAM REFERENCES

TWR-3766	Minuteman III Third Stage Age Sensitivity Component Review
TWR-4082	Test Plan for Full-Scale Minuteman Motors, Third Stage Surveillance Program
TWR-3448	Third Stage Minuteman Propellant Surveillance Program Plan
TWR-3698	Test Plan for Stage III Minuteman Ignition System, Surveillance Program Long Term Storage
TWR-3697	Test Plan for Minuteman AOTT System, Third Stage Surveillance Program
TWR-4290	Quarterly Report, Thiokol Third Stage Minuteman Surveillance, 11 Jul 1970 - 10 Oct 1970
TWR-4394	Quarterly Report, Thiokol Third Stage Minuteman Surveillance, 11 Oct 1970 - 31 Dec 1970
TWR-4647	Quarterly Report, Third Stage Minuteman Surveillance, 16 Apr 1971 - 30 Jun 1971
TWR-4828	Quarterly Report, Third Stage Minuteman Surveillance, 1 Jul 1971 - 30 Sep 1971
TWR-5752	Minuteman III Third Stage Surveillance Semiannual Report, 1 Oct 1971 - 31 Mar 1972
TWR-5674	Test Plan for Pressure Switch Third Stage Surveillance Program
TWR-6233	Minuteman III Third Stage Surveillance Semiannual Report, 1 Apr 1972 - 30 Sep 1972
TWR-6141	Test Plan for Failure Analysis of AGC S/N 0000122, 1128811 Pressure Tank Assembly
TWR-6898	Minuteman III Third Stage Surveillance Semiannual Report, 1 Oct 1972 - 31 Mar 1973
TWR-7012	Failure Analysis of the Pressurization System on Tank Assembly 1128811-329P, S/N 0000122
TWR-7397	Final Report Minuteman III Third Stage Surveillance, 25 Jan 1974
TWR-7484	Minuteman III Third Stage Surveillance Semiannual Report, 1 Jul 1973 - 31 Dec 1973

TWR-7883 Minuteman III Third Stage Surveillance Semiannul Report, 1 Jar 1974 - 28 Feb 1974

TWR-8875 Minuteman III Third Stage Surveillarce Semiannual Report, 1 Mar 1974 - 30 Apr 1975

TWR-9165 Minuteman III Third Stage Surveillance Semiannul Report, 1 May 1975 - 31 Oct 1975

TWR-9577 Minuteman III Third Stage Surveillance Semiannual Report, 1 Nov 1974 - 30 Apr 1976

TWR-9920 Minuteman III Third Stage Surveillance Semiannual Report, 1 May 1976 - 31 Oct 1976

TWR-20304 Minuteman III Third Stage Surveillance Semiannual Report, 1 Nov 1976 - 30 Apr 1977

TWR-20833 Minuteman III Third Stage Surveillance Semiannual Report, 1 May 1977 - 31 Oct 1977

TWR-21170 Minuteman III Third Stage Surveillance Semiannual Report, 1 Nov 1977 - 30 Apr 1978

TWR-21569 Minuteman III Third Stage Surveillance Semiannul Report, 1 May 1978 - 31 Oct 1978

TWR-21897 Minuteman III Third Stage TOP-7 Liquid Injection Thrust Vector Control Failure

TWR-22079 Minuteman III Third Stage Surveillance Semiannual Report, Jun 1979

TWR-22337 Minuteman Third Stage Operational Surveillance Program One-Year Testing, Bondline Aging Study, Sep 1979

TWR-22405 Minuteman III Third Stage Surveillance Semiannual Report, Dec 1979

TWR-22642 Minuteman III Third Stage Surveillance Semiannual Report, Jun 1980

TWR-22965 Minuteman III Third Stage Surveillance Semiannual Report, Dec 1980

TWR-30040 Minuteman Third Stage Operational Surveillance Program, Two-Year Testing Bondline Aging Study, Dec 1980

TWR-30337 Minuteman III Third Stage Surveillance Semiannual Report, Jun 1981

TWR-30565 Failure Analysis of Three Minuteman Third Stage Pressure Switches, 22 Sep 1981

TWR-30721 Minuteman III Third Stage Surveillance Semiarrual Report, Feb 1982

TWR-30790 Failure Analysis of Minuteman (A/D-S&A) Stage III Roll Control Unit, 16 Apr 1982

TWR-30949 Failure Analysis of A/D-S&A Unit P/N 1214110-11, S/N 100537 and 1000128

TWR-30775 Minuteman III Third Stage Surveillance Semiannual Report, Jun 1982

TWR-30814 Minuteman Stage III Operational Surveillance Three-Year Testing and Other Results Bondline Aging Study Final Report, Apr 1982

TWR-31058 Minuteman III Third Stage Surveillance Semiannual Report, Dec 1982

TWR-31248 Failure Analysis of A/D-S&A Unit P/N 1214110-11, S/N 1000151, 1000267, 1000297, 1000733, and 1000833

TWR-31232 Minuteman III Third Stage Surveillance Semiannual Report, Jun 1983

TWR-31309 Final Report of Flight Test GT-92B FTM-5068/Third Stage Motor, S/N TC31068

TWR-31425 Minuteman III Third Stage Surveillance Semiannual Report, Dec 1983

TWR-31501 Minuteman Stage III Operational Surveillance Program Five-Year Testing Bondline Aging Study, Dec 1983

TWR-31647 Minuteman III Third Stage Surveillance Semiannual Report, Jun 1984

TWR-31819 Minuteman III Third Stage Surveillance Semiannual Report, Dec 1984

TWR-31903 Minuteman Stage III Operational Surveillance Program Six-Year Testing Bondline Aging Study, Dec 1984

TWR-32137 Failure Analysis of TOP-26 Roll Control System

TWR-32046 Minuteman III Third Stage Surveillance Semiannual Report, Jun 1985

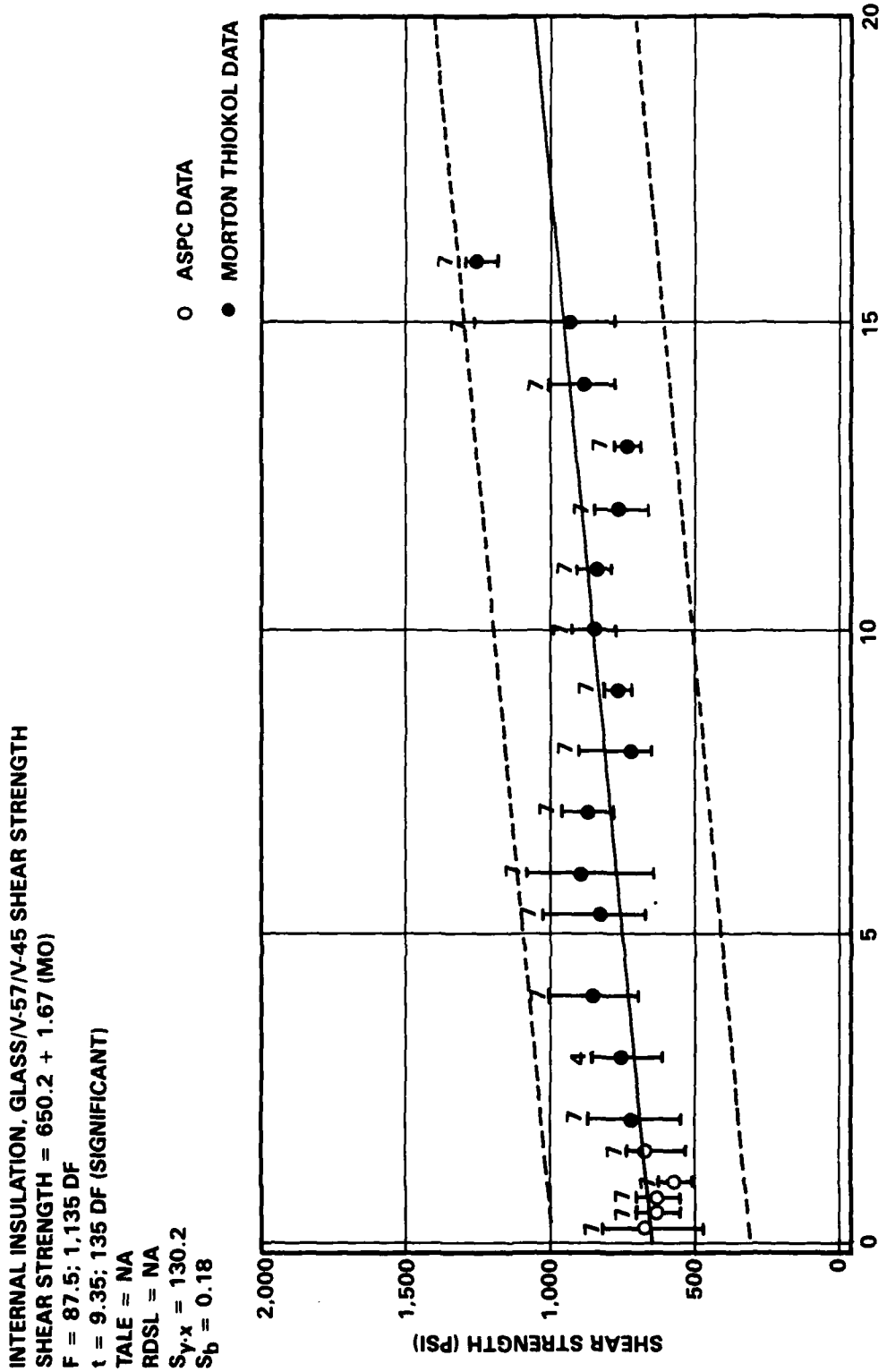

Figure 1. Shear Strength Versus Age, V-45 Rubber/Glass (TP III-022)

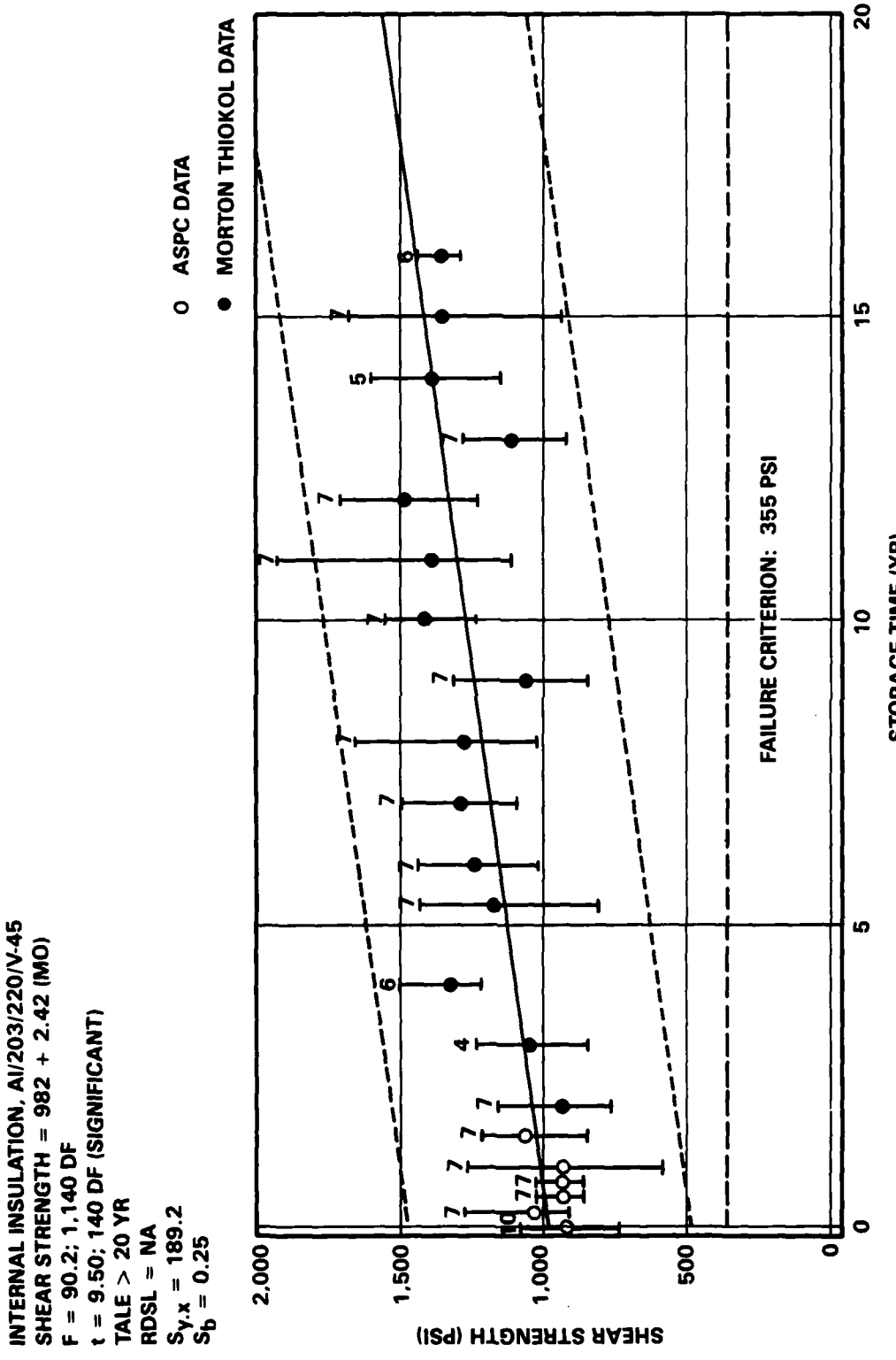

Figure 2. Shear Strength Versus Age, V-45 Rubber/Al (TP III-022)

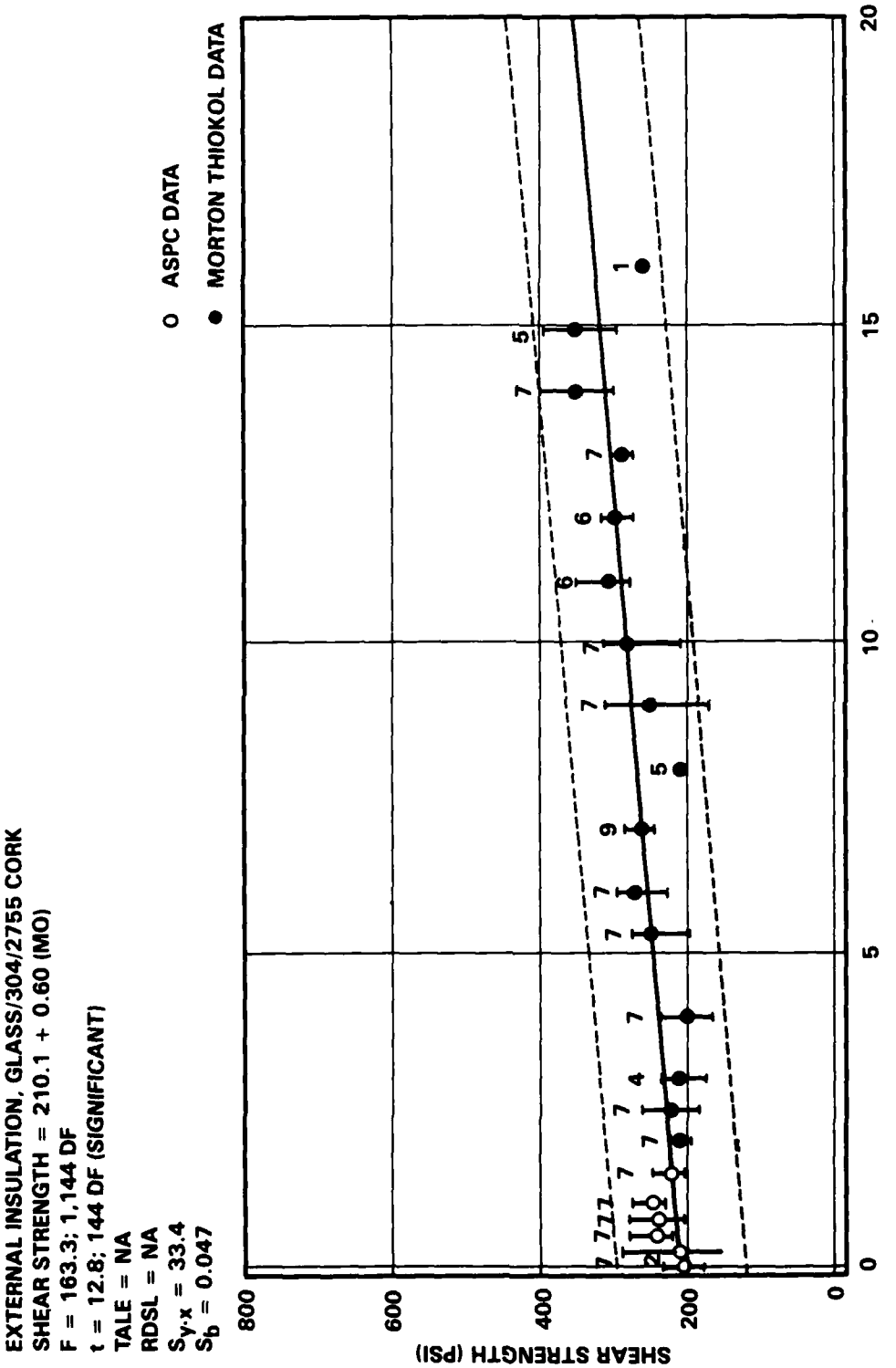

Figure 3. Storage Strength Versus Age, Cork/Glass (TP III-022)

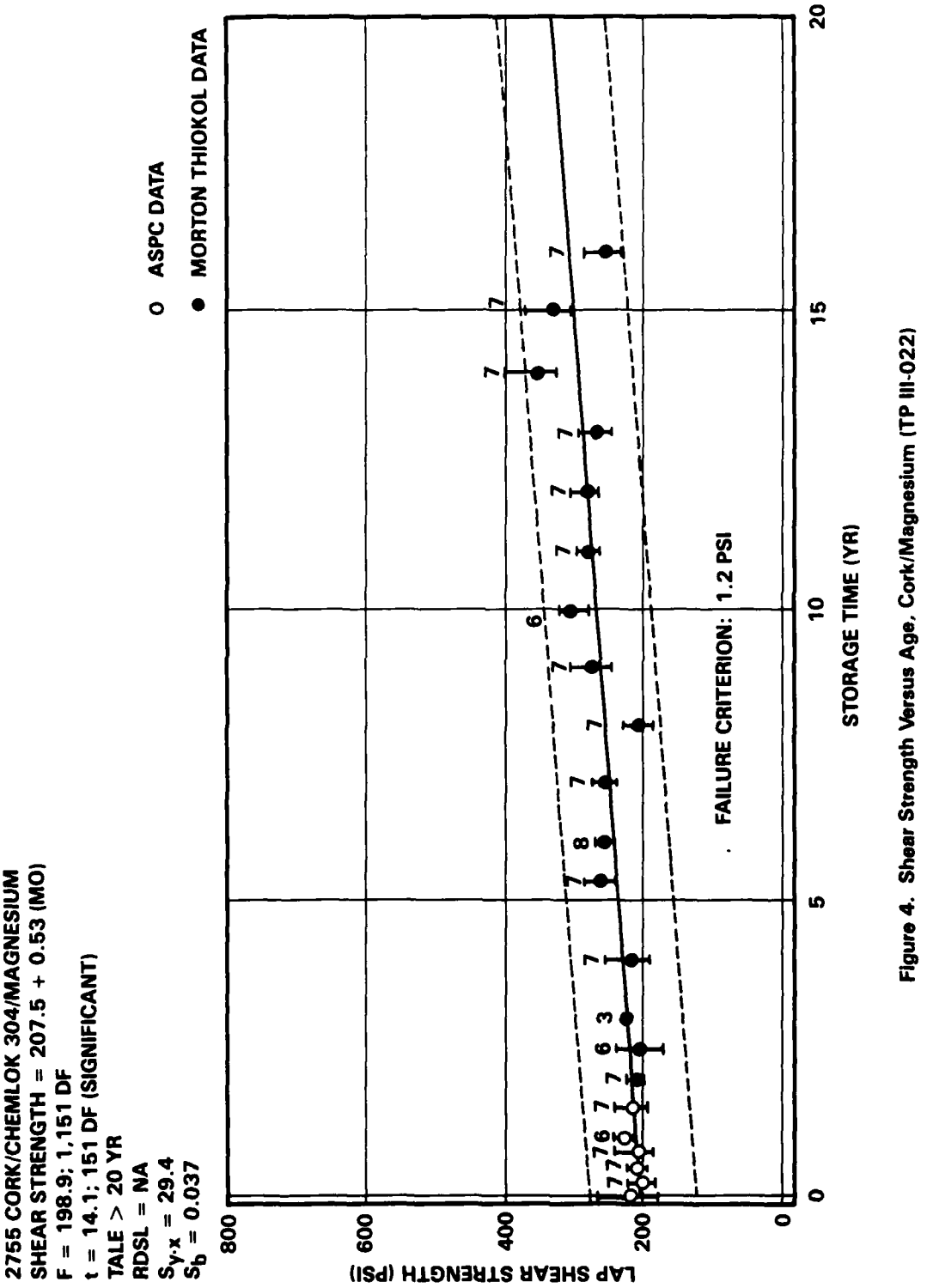

Figure 4. Shear Strength Versus Age, Cork/Magnesium (TP III-022)

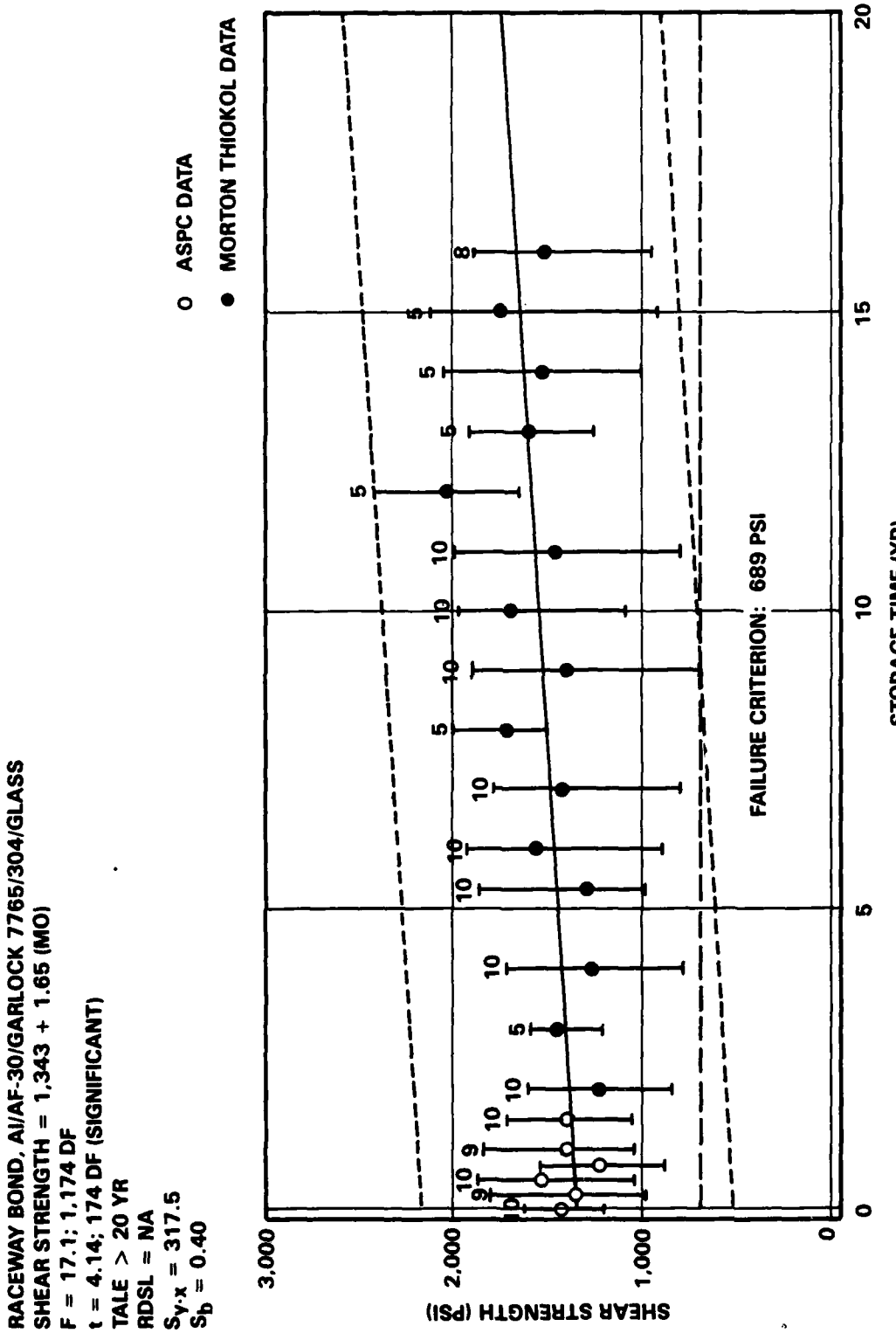

Figure 5. Shear Strength Versus Age, Al/Rubber/Glass (TP III-022)

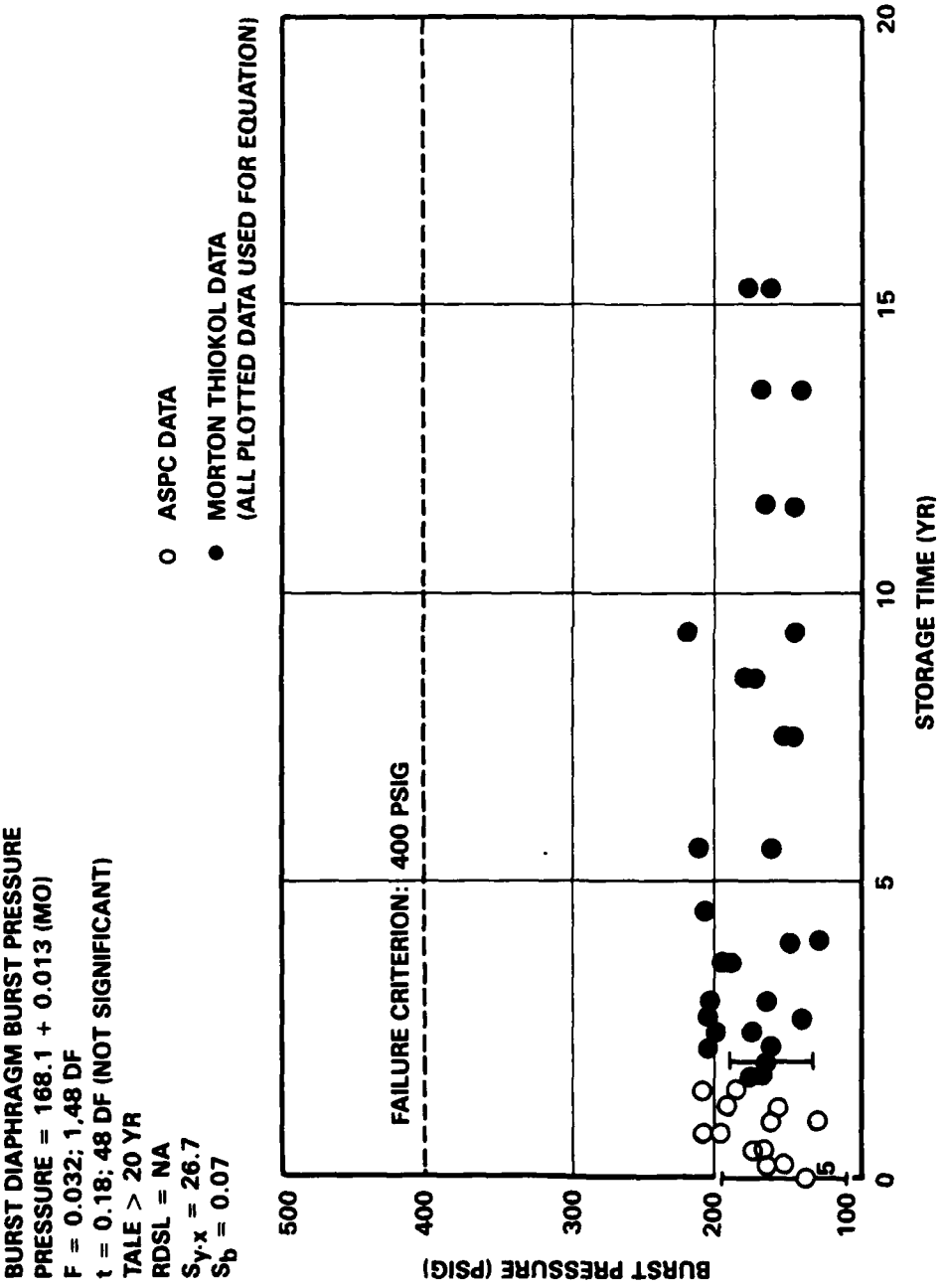

Figure 6. Burst Pressure Versus Age, Burst Diaphragm (TP III-025)

TABLE 1

SURVEILLANCE DOCUMENTATION STATUS

Document Title	Document No.	Revision	Date of Submittal
TCC Age Sensitivity Review	TWR-3766, Rev E	--	--
TCC Quality Program Plan	Rev 4, Task 13.0	5	9/73
TCC Propellant/Liner Plan	TWR-3448, Rev E	F	3/74
TCC AOTT/S&A Plan	TWR-3697, Rev H	J	12/78
TCC Igniter Plan	TWR-3698, Rev F	G	7/75
TCC Motor Plan	TWR-4082, Rev D	E	12/75
TCC Pressure Switch	TWR-5674A	--	--
AFC Age Sensitivity Review	PD III-018E, Changes 1 and 2	--	--
AGC Motor Storage	TP III-019H	J	12/75
AGC Case Aging	TP III-020G	H	6/77
AGC Insulation Aging	TP III-022G	J	12/78
AGC LITVC System Aging	TP III-023D	E	7/75
AGC LITVC Component Aging	TP III-025G	H	12/78
AGC RC System Aging	TP III-026F	G	7/75
AGC RC Component Aging	TP III-027H	J	12/78
AGC TT System Aging	TP III-028I	J	12/78
AGC Igniter Aging	TP III-029C	D	7/75
AGC Nozzle Aging	TP III-069G	H	12/78
AGC Electrical Bond Aging	PD III-094G	H	12/78
AGC DS&R	PD III-125	A	8/73
Bondline Aging	TWR-20946	--	10/78
Addendum No. 2	--	--	6/83

TABLE 2

THIRD STAGE MOTOR COMPONENT STORAGE STATUS (ASPC)

(30 Nov 1985)

Subsystem, Component, and/or Material	Storage Condition (°F)	Sample Number Original	Sample Number Remaining	Storage Period Remaining (mo)	Oldest Test (mo)	Next Test Age (mo)	Next Test Date
A. Chamber, TP III-020 and TP III-022							
1. Full-Scale Case	80 ± 5	3	1	--	72	*	--
2. Subscale Case, 4-in.	80 ± 5	32	0	--	48	--	--
3. NOL Rings							
a. Tensile Test	80 ± 5	70	2	--	60	--	--
b. Shear Test	80 ± 5	15	4	--	60	*	--
4. Insulation							
a. Natural Aging							
(1) V-45/Glass Case	80 ± 5	147	46	21	192	204	9/86
(2) V-45/Aluminum	80 ± 5	147	3	--	192	204	9/86
(3) Cork/Glass Case	80 ± 5	147	0	--	192	--	--
(4) Cork/Magnesium	80 ± 5	147	0	--	192	--	--
(5) Al/Garlock/Glass Case	80 ± 5	195	2	21	192	204	9/86
(6) Neoprene/Glass Case	80 ± 5	138	0	--	178	--	--

*Hold for contingency

TABLE 2 (Cont)

THIRD STAGE MOTOR COMPONENT STORAGE STATUS (ASPC)

(30 Nov 1985)

Subsystem, Component, and/or Material	Storage Condition (°F)	Sample Number Original	Sample Number Remaining	Storage Period Remaining (mo)	Oldest Test (mo)	Next Test Age (mo)	Next Test Date
B. Nozzle, TP III-069							
1. Exit Cone Liner/Nozzle Housing	80 ± 5	70	3	0	180	--	--
2. Rubber Insulation/Nozzle Housing	80 ± 5	70	0	0	180	--	--
3. Aft Exit Cone/Aft Exit Cone Overwrap	80 ± 5	70	4	0	138	--	--
4. Aft Exit Cone Overwrap/Nozzle Housing	80 ± 5	70	0	0	180	--	--
5. Glass-Cloth Overwrap/Nozzle Housing	80 ± 5	70	0	0	180	--	--
6. Aft Exit Cone Liner (MXC-113)							
a. Interlaminar Shear	80 ± 5	70	0	0	138	157	12/84**
b. Ablation	80 ± 5	70	--	--	48	Deleted	
C. Igniter, TP III-029							
Igniter Assemblies	80 ± 5	27	0***	--	76	*	--

*Hold for contingency

**One system taken from FTM-200SP stored on a contingency basis

***Shipped to OOALC Oct 1984

TABLE 2 (Cont)

THIRD STAGE MOTOR COMPONENT STORAGE STATUS (ASPC)
(30 Nov 1985)

Subsystem, Component, and/or Material	Storage Condition (°F)	Sample Number Original	Sample Number Remaining	Storage Period Remaining (mo)	Oldest Test (mo)	Next Test Age (mo)	Next Test Date
D. LITVC, TP III-023 and TP III-025							
1. Subsystems	70 ± 10	10**	6	--	72	*	--
2. Components							
a. Injectant Tank	80 ± 5	3	3	--	Contingency Tanks		
b. Pressure Pack	80 ± 5	6	6 (NDT)	--	48	*	
c. Burst Diaphragms	80 ± 5	50	0	--	186	--	--
E. Thrust Termination System, TP III-028							
1. AOTT Subsystem	80 ± 5	17	1	--	168	Testing Complete	
2. Bond Shear Specimens							
a. Bellows-to-Case	80 ± 5	83	3	--	156	Testing Complete	
b. Clamp-to-Bellows-to-Stack	80 ± 5	83	3	--	168	Testing Complete	
c. LSC Retainer-to-Case	80 ± 5	88	12	12	156	180	12/85
3. Tensile Tests							
a. Viton Reinforced W/Dacron	80 ± 5	88	5	--	168	Testing Complete	

*Hold for contingency

**One system taken from FTM-200SP stored on a contingency basis

TABLE 2 (Cont)

THIRD STAGE MOTOR COMPONENT STORAGE STATUS (ASPC)

(30 Nov 1985)

Subsystem, Component, and/or Material	Storage Condition (°F)	Sample Number Original	Sample Number Remaining	Storage Period Remaining (mo)	Oldest Test (mo)	Next Test Age (mo)	Next Test Date
4. LSC Retainer Mount-to-Case Bond Tensile Specimens							
a. Normal Aging	80 ± 5	10	10 (NDT)	17	180	192	4/86
b. Accelerated Aging	125 ± 5	10	10 (NDT)	--	15	Testing Complete	
5. LSC Retainer Load Test	80 ± 5	10	10 (NDT)	15	180	192	2/86
F. Roll Control, TP III-026 and TP III-027							
1. Roll Control Subsystem	70 ± 10	7	5	--	46	*	--
2. Component							
a. Gas Generators	80 ± 5	20	6	--	36	*	--
b. Valve Assembly	70 ± 10	3	3 (NDT)	23	180	192	12/85
c. Propellant	80 ± 5	33	0	--	156	Testing Complete	
d. Ignition Wafers on Dome Insulators	80 ± 5	42	0	--	156	Testing Complete	

*Hold for contingency

TABLE 2 (Cont)

THIRD STAGE MOTOR COMPONENT STORAGE STATUS (ASPC)
(30 Nov 1985)

Subsystem, Component, and/or Material	Storage Condition (°F)	Sample Number Original	Sample Number Remaining	Storage Period Remaining (mo)	Oldest Test (mo)	Next Test Age (mo)	Next Test Date
G. Electrical Bonds, TP III-094							
Natural Aging							
1. Raceway Electrical Bond	80 ± 5	11	11 (NDT)	24	180	192	12/85
2. Strip/Forward Ring	80 ± 5	6	6 (NDT)	24	180	192	12/85
3. Strip/Aft	80 ± 5	6	6 (NDT)	24	180	192	12/85
4. Conductive Finish	80 ± 5	20	20 (NDT)	24	180	192	12/85
5. Forward Skirt/Interstage	80 ± 5	6	6 (NDT)	24	180	192	12/85
6. Cables	80 ± 5	5	5 (NDT)	--	84	*	--
7. Cork Specimens	80 ± 5	70	4	--	168	Testing Complete	
8. Full-Scale Case	80 ± 5	1	1 (NDT)	18	168	180	5/86

*Hold for contingency

TABLE 3

AGING SAMPLE SUMMARY (MORTON THIOKOL)
(30 Nov 1985)

Sample	Aging Temperature (°F)	Sample Number Original	Sample Number Remaining	Storage Period Remaining (mo)	Oldest Test Age (mo)	Oldest Test Date	Next Test Age (mo)	Next Test Date
A. Thrust Termination								
1. System	--	10	0	0	168	4/84	Complete	
2. A/D-S&A Mechanism	--	8	1	0	120	4/84	Complete	
B. Igniter	--	24	0*	--	49/61	9/75	--	--
C. Propellant Bulk Samples								
1. Characterization (1 gal)								
Mix 6500003	80	12	3	--	60	8/75	--	**
Mix 6500004	80	12	3	--	60	8/75	--	**
Mix 6500005	80	12	3	--	60	8/75	--	**
Mix 6500006	80	12	3	--	60	8/75	--	**
2. Accelerated Aging (9 x 9)								
Mix 6500002	110	8	2***	0	12	8/75	Complete	
	135	8	2***	0	12	8/75	Complete	
3. Batch Variation (9 x 9)								
Mix 6300016	80	1	1	--	12	8/75	--	**
Mix 6300017	80	1	1	--	12	8/75	--	**
Mix 6500001	80	0	1	0	12	8/75	--	--
Mix 6500002	80	4	3	--	24	8/75	--	**
Mix 6500003	80	3	0	0	24	8/75	--	--
Mix 6500004	80	3	0	0	48	8/75	--	--
Mix 6500005	80	4	2	0	24	8/75	--	--
Mix 6500006	80	3	0	0	48	8/75	--	--
4. Failure Criteria								
Mix 6300016	80	44	17	--	72	8/75	--	**
Mix 6300017	80	38	12	--	72	8/75	--	**
Mix 6500001	80	51	19	--	72	8/75	--	**
D. Strain Evaluation Motors								
Mix 6500004	80	10	8	0	120	8/80	Complete	

*Shipped to OOALC Oct 1984
**Hold for contingency test
***6-mo tests not performed

TABLE 4

THIRD STAGE AGED MOTOR DEMONSTRATIONS STATUS
(THRU 30 NOV 1985)

Oldest Static Test			Oldest Flight Test		
Motor	Date	Age (mo)	Motor	Date	Age (mo)
TOP-24	5/84	153	FTM-5297	9/84	148
			TC30139		

TABLE 5

SUMMARY OF MINUTEMAN III THIRD STAGE MOTOR TEST
(DURING THIS REPORT PERIOD - 31 MAY 1985 THRU 30 NOV 1985)

Motor Designation	Cast Date	Fire Date	Age (mo)	Flight Test I	Static Test	Type of Cure		Aft End Design		Success/ Failure
						Ambient	Pressure	Flap	Non-Flap	
FTM-5116 (TC31121)	8/31/78	6/16/85	82	X			X	X		S
FTM-5488 (TC30328	10/18/73	6/16/85	140	X			X	X		S
FTM-5056 (TC31079)	6/23/78	7/15/85	85	X			X	X		S

TABLE 6

INSULATION SPECIMEN AGING DATA

Configuration	Storage Time (mo)	Storage Temp (°F, 5*)	Lap Shear Strength (psi)	Sigma (psi)	Failure Mode (%) V-57/Rubber	Failure Mode (%) V-57/Glass
1. Glass/V-57/V-45	0*	80	463	62	100	--
	3*	80	676	123	46	54
	6*	80	630	51	65	35
	9*	80	674	90	59	41
	12*	80	570	43	75	25
	18*	80	670	69	71	29
	24	80	721	110	50	50
	30	80	520	183	51	49
	36	80	760	106	94	6
	48	80	853	106	100	--
	64	80	828	85	60	40
	72	80	894	149	64	36
	84	80	866	66	--	100
	96	80	722	85	33	67
	108	80	760	33	35	65
	120	80	844	57	99	1
	132	80	835	41	28	72
	144	80	764	62	36	64
	156	80	735	33	--	100
	168	80	883	91	24	76
	180	80	925	155	--	100
	192	80	1,256	32	--	100

* ASPC Data

TABLE 6 (Cont)

INSULATION SPECIMEN AGING DATA

Configuration	Storage Time (mo)	Storage Temp (°F, 5*)	Lap Shear Strength (psi)	Sigma (psi)	Failure Mode (%) 220/Rubber	Al/203	Rubber
2. Al/203/220/V-45	0*	80	922	94	98	--	2
	3*	80	1,039	135	100	--	--
	6*	80	936	73	98	2	--
	9*	80	1,027	138	100	--	--
	12*	80	930	214	100	--	--
	18*	80	1,065	152	95	5	--
	24	80	933	158	100	--	--
	30	80	613	85	98	2	--
	36	80	1,050	164	100	--	--
	48	80	1,325	111	97	--	--
	64	80	1,178	198	96	4	3
	72	80	1,241	154	97	3	--
	84	80	1,289	153	92	8	--
	96	80	1,278	201	96	4	--
	108	80	1,063	155	94	6	--
	120	80	1,417	115	69	30	1
	132	80	1,389	296	86	14	--
	144	80	1,483	182	89	11	--
	156	80	1,115	114	89	--	--
	168	80	1,394	175	100	--	--
	180	80	1,355	238	100	--	--
	192	80	1,360	58	--	100	--

* ASPC Data

TABLE 6 (Cont)

INSULATION SPECIMEN AGING DATA

Configuration	Storage Time (mo)	Storage Temp (°F, 5*)	Lap Shear Strength (psi)	Sigma (psi)	Failure Mode (%) 304/Cork	Cork	304/Glass	Cohesive/304	304/Al
3. Glass/304/2755 Cork	0*	80	204	--	--	91	9	--	--
	3*	80	211	40	--	98	2	--	--
	6*	80	238	26	--	100	--	--	--
	9*	80	215	13	--	100	--	--	--
	12*	80	245	15	--	100	--	--	--
	18*	80	224	15	--	98	--	--	--
	24	80	215	9	--	96	4	--	--
	30	80	225	36	--	72	10	14	4
	36	80	211	28	19	81	--	--	--
	48	80	204	25	--	71	28	--	1
	64	80	250	29	--	83	17	--	--
	72	80	272	22	--	93	4	3	--
	84	80	261	14	--	100	--	--	--
	96	80	209	3	--	100	--	--	--
	108	80	247	42	--	87	13	--	--
	120	80	280	33	--	95	5	--	--
	132	80	303	28	--	100	--	--	--
	144	80	299	18	--	100	--	--	--
	156	80	288	13	--	89	11	--	--
	168	80	350	33	--	100	--	--	--
	180	80	352	43		100	--	--	--
	192	80	261	--	--	100	--	--	--

*ASPC Data

TABLE 6 (Cont)

INSULATION SPECIMEN AGING DATA

Configuration	Storage Time (mo)	Storage Temp (°F, 5*)	Lap Shear Strength (psi)	Sigma (psi)	Failure Mode (%) Cork	304/MG	304/AT
4. MG/304/2775 Cork	0*	80	218	33	97	3	--
	3*	80	201	12	92	2	--
	6*	80	211	7	100	--	--
	9*	80	208	20	100	--	--
	12*	80	225	11	100	--	--
	18*	80	216	16	--		--
	24	80	209	8	100	--	--
	30	80	205	25	40	--	60
	36	80	223	1	99	1	--
	48	80	218	20	89	11	--
	64	80	261	15	100	100	--
	72	80	260	7	--	--	--
	84	80	259	10	100	--	--
	96	80	206	15	100	--	--
	108	80	274	22	100	--	--
	120	80	302	15	100	--	--
	132	80	278	11	100	--	--
	144	80	280	12	100	--	--
	156	80	266	14	100	--	--
	168	80	350	27	100	--	--
	180	80	327	25	100	--	--
	192	80	257	21	87	13	--

TABLE 6 (Cont)

INSULATION SPECIMEN AGING DATA

Configuration	Storage Time (mo)	Storage Temp (°F, 5*)	Lap Shear Strength (psi)	Sigma (psi)	Failure Mode (%) AF-30	AF-30/7765	7765 Rubber	7765/304	304-304/Glass	
5. Aluminum/AF-30/ Garlock 7765/304/ Glass	0**	80	1,430	153	2	4.0	--	15.0	2.0	77.0
	3**	80	1,411	243	6	7.0	--	29.0	7.0	51.0
	6**	80	1,538	237	1	20.0	--	76.0	--	3.0
	9**	80	1,220	218	25	25.5	0.5	4.0	2.0	43.0
	12**	80	1,399	285	7	23.5	--	47.5	11.5	10.5
	18**	80	1,402	209	10	26.0	--	42.0	3.0	19.0
	24	80	1,233	287	--	38.0	--	--	--	62.0
	30	80	854	268	27	14.0	--	29.0	25.0	--
	36	80	1,455	163	--	9.0	--	--	21.0	70.0
	48	80	1,265	342	37	--	5.5	--	57.5	--
	64***	80	1,304	305	16	--	2.0	30.0	--	52.0
	72	80	1,567	326	--	--	4.0	20.0	4.0	72.0
	84	80	1,430	309	--	--	--	25.0	--	75.0
	96	80	1,721	256	--	--	--	21.0	--	79.0
	108	80	1,403	361	21	27	--	--	--	52
	120	80	1,705	276	26	--	--	25.0	--	49
	132	80	1,456	427	--	--	--	85.0	--	15
	144	80	2,038	290	15	85	--	--	--	--
	156	80	1,599	243	--	21	--	75.0	4.0	--
	168	80	1,525	385	--	--	--	20.0	--	80.0
	180	80	1,750	500		--	--	20.0		80.0
	192	80	1,518	310	--	50.0	--	--	--	50.0

TABLE 7

BURST DIAPHRAGM TEST DATA

Storage Time (MO)	Burst Pressure (psig)	Strontium Perchlorate (%)	Free Cloride (ppm)
Zero**	108 to 191*	66.78	42.5
3**	161	65.37	18
	151		
6**	172	65.90	30
	165		
9**	192	66.06	23
	207		
12**	130	65.86	26
	160		
15**	190	66.38	18
	156		
18**	206		
	184		
21	176	64.5	20.2
	169		
24	131	63.6	27
	188		
	176	63.7	30
	165		
27	204	64.6	25
	160		
30	172	64.0	13.1
	199		
33	140	65.75	19.0
	203		
36	163	65.6	36.0
	203		
42	187	66.08	18.0
	192		
48	128	66.5	22.0
	148		
54	205***	67.64	16.0
66	211	65.8	32.8
	161		
90	150	66.1	34.8
	158		
102	172	63.2	31.1
	176		
114	220	64.95	17
	150		
138	166	65.6	22
	144		
162	167		
	139	65.6	19.7
186	178	66.1	34.6
	169		
Specification Limits	100 to 400	65 to 67	60 max

*Zero time range of test values, average 138.
**ASPC Data.
***S/N 45 leaked during filling at 65-70 psig.

TABLE 8

DEMONSTRATED SERVICE LIFE

Motor/Subsystem	Demonstrated Useful Life (yr) Motor	Subsystem*
Motor		12.8 (TOP-24)
Chamber, Internal Insulation		12.8 (TOP-24)
Chamber, Forward Dome		12.8 (TOP-24)
Nozzle		12.8 (TOP-24)
Igniter		12.8 (TOP-24)
LITVC, Injectant Tank, and Pressure Pack		12.8 (TOP-24)
Helium Tank		12.8 (TOP-24)
TT System		12.8 (TOP-24)
RC System		12.8 (TOP-24)
Propellant		12.8 (TOP-24)
External Insulation		12.3 (FTM-5297)

*Based on the indicated motor and subsystem tests

NOTE: Initial service life estimate - 6 years

TABLE 9

PARTS MINIMUM SERVICE LIFE (PMSL)

Subsystem	Component or Interface	Predictive Parameter	Failure Criteria	Level of Assembly for Test	Trend Significant	TALE (yr)	Figure Ref
I. Chamber	A. 440-ksi Glass Composite	1. Burst Pressure	3,150 psia (subscale)	L	--	--	--
		2. Tensile Strength	184,740 psi (NOL ring)		--	--	--
	B. 440-ksi Glass and Glass Tape Composite	Shear Strength of the Composite	8,358 psi Min	L	--	--	--
	C. V-45 Internal Insulation	1. Ablation Rate	10 mils/sec Max	L (Wing VI data)*	--	--	--
		2. Ablation	Noninsulation Remaining at Point of Measure	M	--	--	--
		3. Tensile Strength	1,140 psi Min	L (Wing VI data)	--	--	--
		4. Elongation	130% Min	L (Wing VI data)	--	--	--
	D. Cork/Magnesium Bond	Bond Shear Strength	1.2 psi Min	L	Yes	20	4

Note:
S - Subsystem assembly
C - Component
L - Lab specimen
M - Motor

*Wing VI ablation reported as total regression depth and not comparable to failure criteria
Wing VI data are provided as supporting data

TABLE 9 (Cont)

PARTS MINIMUM SERVICE LIFE (PMSL)

Subsystem	Component or Interface	Predictive Parameter	Failure Criteria	Level of Assembly for Test	Trend Significant	TALE (yr)	Figure Ref
I. Chamber (Cont)	E. Raceway Bond	Bond Shear Strength	698 psi Min	L	Yes	20	5
	F. Support Pad	Bond Shear Strength	69.4 psi Min	L	Yes	20	--
	G. Cork External	Ablation Rate	20.5 mils/sec Max	L (Wing VI data)*	--	--	--
	H. V-45/Aluminum	Shear Strength	323 psi Min	L	Yes	20	2
II. Nozzle	A. Entrance Cap	1. Ablation Rate	21.8 mils/sec Max	L (Wing VI data)	--	--	--
		2. Tensile Strength	1,400 psi Min	L (Wing VI data)	--	--	--
	B. Fwd Exit Cone MX4926	Ablation Rate	0.29 in. Max	M	--	--	--
	C. Aft Exit Cone MXC113	Ablation Rate	5.0 mils/sec Max	L	No	20	--
	D. MX4926/Aluminum Bond	Bond Shear	920 psi Min	L	Yes	20	--

Note:
S - Subsystem assembly
C - Component
L - Lab specimen
M - Motor

*Wing VI ablation reported as total regression depth and not comparable to failure criteria
Wing VI data are provided as supporting data

TABLE 9 (Cont)

PARTS MINIMUM SERVICE LIFE (PMSL)

Subsystem	Component or Interface	Predictive Parameter	Failure Criteria	Level of Assembly for Test	Trend Significant	TALE (yr)	Figure Ref
II. Nozzle (Cont)	E. V-44/Aluminum Bond	Bond Shear	240 psi Min	L	No	20	--
	F. MXB6001/MXC113	Bond Shear	432 psi Min	L	No	20*	--
	G. Aluminum/Overwrap (MXB6001) Bond	Bond Shear	684 psi Min	L	Yes	20	--
	H. Glass Cloth/Aluminum Bond	Bond Shear	189 psi Min	L	Yes	20	--
	I. MXC113	Shear Strength	537 psi Min	L	Yes	20	--
III. Igniter	A. Ignition Train	Igniter Delay	43 msec Max	M, S	--	--	--
		Motor Delay	200 msec Max	M	--	--	--
	B. ANB 30 Propellant	1. Igniter Maximum Pressure	2,036 psia Max	M, S	--	--	--
		2. Igniter Average Operating Pressure	1,873 psia Min	M, S	--	--	--
	C. Ignition Mass Flow	Interstage Pressure	40 psia Max	M	--	--	--

Note:
S - Subsystem assembly
C - Component
L - Lab specimen
M - Motor

*Based on tests at Wasatch Division between 2 and 7 years

TABLE 9 (Cont)

PARTS MINIMUM SERVICE LIFE (PMSL)

Subsystem	Component or Interface	Predictive Parameter	Failure Criteria	Level of Assembly for Test	Trend Significant	TALE (yr)	Figure Ref
IV. LITVC	A. Pressure Pack	1. Relief Pressure	770 ± 25 psia	C	--	--	--
		2. Minimum Injectant	655 psia Min	M, S	--	--	--
	B. Burst Diaphragms	Burst Pressure	250 ± 150 psia	L	No	20	6
	C. Liquid Hammer Suppressor	Injector Valve Inlet Pressure Maximum	1,875 psia Max	M, S	--	--	--
	D. Squib Valve, Regulator, Burst Diaphragms and Suppressor	System Pressurization Time	1.3 ± 0.3 sec	M, S	--	--	--
	E. LITVC System Weight	*Delivered Injectant*	*41.1 lb Min*	--	--	--	--
	F. Helium Tank	Helium Tank Pressure	*	M, S	--	--	--
V. Thrust Termination	A. Ordnance	System Functioning Time	705 μsec Max	S	Yes	20	--
	B. Linear Shaped Charge (LSC)	Blast Penetration Depth	0.100 in. Min (aluminum witness plate)	S	No	20	--
	C. LSC Retainer	Bond Tensile Strength	No Failure at 300-lb Minimum Tensile Load	L	--	--	--

Note:
S - Subsystem assembly
C - Component
L - Lab specimen
M - Motor

*No-go indication of the pressure switch will be considered a failure. Pressurization capability will be monitored by recording tank pressure available after 41.8 lb of strontium is expelled in the subsystem injection cycle

TABLE 9 (Cont)

PARTS MINIMUM SERVICE LIFE (PMSL)

Subsystem	Component or Interface	Predictive Parameter	Failure Criteria	Level of Assembly for Test	Trend Significant	TALE (yr)	Figure Ref
V. Thrust Termination (Cont)	D. Bellows/Case Bond	Bond Shear Strength	1,356 psi Min	L	No	20	--
	E. Stack/Bellows Bond	Bond Shear Strength	660 psi Min	L	Yes	20	--
	F. LSC Retainer/ Case Bond	Bond Shear Strength	360 psi Min	L	Yes	20	--
VI. Roll Control	A. Gas Generator	1. Gas Generator Pressure at 13.6 sec (60°F)	870 psia Min	M, S, C	--	--	--
		at 60 sec (60°F)	650 psia Min	--	--	--	--
			1,754 psia Max	--	--	--	--
		2. Action Time (60°F)					
	B. RC Valve	Valve Response Time	--	M, S	--	--	--
		A. Null to Hardover	0.038 sec Max	--	--	--	--
		B. Hardover to Null	0.039 sec Max	--	--	--	--
		C. A + B	0.19 sec Max	--	--	--	--
		D. Hardover to Hardover	0.050 sec Max	--	--	--	--
	C. Propellant (ARP)	Bond Shear Strength	53.6 psi Min	L	No	20	--

Note:
S - Subsystem assembly
C - Component
L - Lab specimen
M - Motor

TABLE 9 (Cont)

PARTS MINIMUM SERVICE LIFE (PMSL)

Subsystem	Component or Interface	Predictive Parameter	Failure Criteria	Level of Assembly for Test	Trend Significant	TALE (yr)	Figure Ref
VI. Roll Control (Cont)	D. Booster Propellant (ARP 200)/ Dome Insulator Bond						
	E. Sustainer Propellant (ARP 421)/ Dome Insulator Bond	Bond Shear Strength	18.6 psi Min	L	No	20	--
	F. Propellant	Strain at Break	2.3% Min	L	Yes	20	--
	G. Generator Ignition	Ignition Delay (time to 870 psia at 60°F)	0.6 sec Max	M, S, C	--	--	--
VII. Block IV Specimens	Cork/Glass	Bond Shear Strength	52 psi Min	L	Yes	20	--
	Electrical Cables	Attenuation	60 dB	C	--	--	--
	Raceway Skirts	Electrical Resistance	1 mΩ	L	No	20	

Note:
S - Subsystem assembly
C - Component
L - Lab specimen
M - Motor

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